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DECLARATION

I, TOSHIFUMI ONUKI, c/o TMI ASSOCIATES, 23rd Floor, Roppongi Hills Mori Tower, 6-10-1 Roppongi, Minato-ku, Tokyo 106-6123, Japan, do solemnly and sincerely declare that I well understand the Japanese and English languages and that the attached English version is full, true and faithful translation made by me this 10th day of July 2004 of Japanese Patent Application No. 2000-402809 filed before the U.S. Patent and Trademark Office on the 28 day of December 2000.

In testimony whereof, I have hereunto set my name and seal this 10th day of July 2004.

July 10, 2004

TOSHIFUMI ONUKI

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[Title of Invention] A Method of Forming a Silicon Thin-Film

[Claims]

[Claim 1]

A method of forming a silicon thin-film, comprising:

arranging iquid which contains a silicide comprising ring silane and/or a derivative thereof is arranged in one or more parts of a substrate, said ring silane comprising silicon and hydrogen; and

vaporizing and supplying silicide from said liquid to a thin-film-forming surface to form a silicon thin-film by a chemical vapor deposition (CVD) method.

[Claim 2]

A method of forming a silicon thin-film according to claim 1, wherein a solution, in which cyclopentasilane and/or silylcyclopentasilane are/is dissolved in an organic solvent, is used as liquid which contains a silicide.

[Claim 3]

A method of forming a silicon thin-film according to claim 1 or 2, wherein said thin-film-forming surface is said liquid arranging surface of said substrate.

[Claim 4]

A method of forming a silicon thin-film according to claim 1 or 2, wherein a first substrate for arranging liquid and a second substrate for forming a thin-film are arranged in a manner that a liquid arranging surface of said first substrate and a thin-film-forming surface of said second substrate face each other, and silicide is vaporized from said liquid arranged on one or more parts of said first substrate and supplied to said thin-film-forming surface on said second substrate.

[Claim 5]

A method of forming a silicon thin-film according to claim 4, wherein said second substrate is heated so as to have a temperature at which said thin-film-forming surface can decompose a vaporizing matter of silicide, and by the heat emitted from said second substrate pursuant to the heating, said first substrate is heated to a temperature at which silicide is vaporized from said liquid.

[Claim 6]

A method of forming a silicon thin-film according to any one of claims 1 to 5, wherein, before performing said step of arranging said liquid, an active region and inactive region for CVD is formed on said thin-film-forming surface so that a silicon thin-film is selectively deposited.

[Claim 7]

A method of forming a silicon thin-film according to claim 4, wherein a self-assembled film is formed on said thin-film-forming surface in which a hydroxyl group exists, using a silane derivative indicated by the general formula $RSiX_3$ (R is a fluoroalkyl group in which hydrogen on an end side of an alkyl group is substituted with fluorine and X is an alkoxy group or a hologen group), then, an ultraviolet ray irradiation through a photomask to said self-assembled film or electron beam irradiation to a necessary part of said self-assembled film is performed and a part of said self-assembled film which becomes an active region for CVD is removed, so that an active region and an inactive region for CVD are formed.

[Claim 8]

A method of forming a silicon thin-film according to any one of claims 1 to 7, wherein said step of vaporizing said silicide is

performed while running an inactive gas, a hydrogen gas or a mixed gas of an inactive gas and a hydrogen gas, in parallel with said liquid arranging surface of said substrate.

[Claim 9]

A method of forming a silicon thin-film according to any one of claims 1 to 8, wherein said step of arranging said liquid is performed by an inkjet method.

[Detailed Description of Invention]

[0001]

[Field of the Invention]

The present invention relates to a method of forming a silicon thin-film by a chemical vapor deposition (CVD) method.

[0002]

[Related Arts]

In a process of manufacturing an integrated circuit or a thin-film translator, etc., conventionally, a silicon thin-film has been formed by a CVD method, using a monosilan gas or a disilan gas. A polysilicon thin-film is generally formed by a thermal CVD method and an amorphous silicon thin-film is formed by a plasma-activated CVD method. Then, in order to obtain a predetermined pattern of a silicon thin-film, after forming a silicon thin-film on an entire substrate, a patterning process, which removes an unnecessary part by photolithography and etching using a resist, has been performed.

[0003]

However, the aforementioned method of forming a silicon thin-film pattern using the process of forming a film by the CVD method and the patterning process has problems.

(1) Since gaseous hydrosilicon of high toxicity and reactivity is used, a pressure chamber or a vacuum device is required; (2)

Especially in a plasma-activated CVD method, a complex and costly high frequency generator or vacuum device is required; (3) a patterning process, which has complex steps and is inefficiently uses materials, generates a large amount of waste such as a resist or etchant, etc; and (4) CVD devices are expensive and consume enormous energy for a vacuum system or plasma system; therefore, the cost of forming a film is high.

[0004]

Meantime, in recent years, methods of forming a silicon thin-film without using a vacuum device have been suggested. For example, the Japanese Patent Laid-Open Publication No. hei 9-237927 discloses a method of, after applying a polysilane solution containing an alkyl group on a substrate, thermally decomposing polysilane to liberate a silicon film. This method, however, has a problem that a silicon thin-film of high electric characteristics can not be obtained, as carbon, which comprises polysilane, which is a material, remains in the silicon thin-film.

[0005]

Meanwhile, the Japanese Patent Laid-Open Publication No. 2000-12465 discloses a method of arranging a first silicon film-formed body and a second silicon film-formed body, on a film-forming surface of which a liquid material is applied, both film-forming surfaces facing each other, thereby forming at the same time a silicon film on both film-forming surfaces of the first silicon film formed body and the second silicon film formed body. As a liquid material, liquid silane, which is a silicide not containing carbon and indicated by the general formula Si_nH_{2n+2} or Si_nH_{2n} ($3 \leq n \leq 7$), is used.

[0006]

This Publication further describes the method that, on the film-forming surface of the first silicon film-formed body, a silicon film is formed by a decomposing reaction of the liquid material applied, and on the film-forming surface of the second silicon film-formed body, a silicon film is formed by a decomposing reaction of a vaporizing matter of the liquid material on the film-forming surface of the first silicon film-formed body.

[0007]

[Problems Which the Invention Intends to Solve]

However, in any method described in any of the aforementioned Publications, in order to obtain a predetermined pattern of a silicon film, it is necessary to perform a patterning process after forming a film.

The present invention is suggested focusing on these problems of the related art. That is, an object of the present invention is to provide a method of forming a silicon thin-film in a CVD method that requires no vacuum device that uses a liquid material, particularly, a method of forming a silicon thin-film on a part of a substrate by using a small amount of a liquid material and obtaining a predetermined pattern of a silicon thin-film without the necessity to perform patterning after forming the thin-film.

[0008]

[Means of Solving the Problems]

In order to achieve the above objects, the present invention is a method of forming a silicon thin-film, wherein liquid which contains a silicide comprising ring silane and/or a derivative thereof is arranged in one or more parts of a substrate, the ring silane comprising silicon and hydrogen, and silicide is vaporized from the liquid and suppled to a thin-film-forming surface to form a silicon

thin-film by a chemical vapor deposition (CVD) method.

[0009]

According to this method, a silicon thin-film can be formed only on a part of a thin-film surface (in the neighborhood of a liquid arranging position). This liquid is arranged only in the neighborhood of a device-forming region on a thin-film-forming surface, whereby a silicon thin-film is formed only in the device-forming region on a thin-film-forming surface and in the neighborhood thereof. Consequently, even when a silicon thin-film is formed only on a small part of a large area substrate, it is possible to restrain consumption of materials for a thin-film to a tiny amount.

[0010]

Here, examples of silicide (ring silane and/or a derivative thereof, the ring silane comprising silicon and hydrogen) which can be used in the method of the present invention are: cyclopentasilane, silylcyclopentasilane, cyclohexasilane, silylcyclohexasilane, cycloheptasilane, 1,1'-biscyclobutasilane, 1,1'-biscyclopentasilane, 1,1-biscyclohexasilane, 1,1'-biscycloheptasilane, 1,1'-cyclobutasilylcyclopentasilane, 1,1'-cyclobutasilylcyclohexalane, 1,1'-cyclobutasilylcycloheptasilane, 1,1'-cyclopentasilylcyclohexasilane, 1,1'-cyclopentasilylcycloheptasilane, 1,1'-cyclohexasilylcycloheptasilane, spiro[2,2]pentasilane, spiro[3,3]heptasilane, spiro[4,4]nonasilane, spiro[4,5]decasilane, spiro[4,6]undecasilane, spiro[5,5]undecasilane, spiro[5,6]dodecasilane, spiro[6,6]tridecasilane, etc.

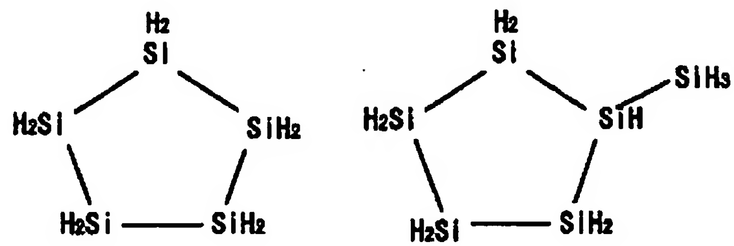
[0011]

For a liquid containing silicide used in the method of the present invention, it is preferable to use a solution in which

cyclopentasilane indicated in the chemical formula (1) below and/or silylcyclopentasilane indicated in the chemical formula (2) below are dissolved in an organic solvent.

[0012]

[Chemical Formula 1]



(a) (b)

(*(a) refers to (1) and (b) refers to (2))

[0013]

In the method of the present invention, a thin-film-forming surface is a liquid-arranging surface, whereby, a silicon thin-film can be formed only using a substrate for forming a silicon thin-film, not using a dummy substrate for arranging liquid.

In the present invention, a first substrate for arranging liquid and a second substrate for forming a thin-film are arranged in a manner that a liquid arranging surface of the first substrate and a thin-film-forming surface of the second substrate face each other, and silicide is vaporized from the liquid arranged on one or more parts of the first substrate and supplied to the thin-film-forming surface on the second substrate, so that a silicon thin-film is formed on the thin-film forming surface of the second substrate opposite to the liquid arranging surface of the first substrate.

[0014]

These two substrates are used in a manner that the second substrate is heated so as to have a temperature at which the thin-film-forming surface can decompose a vaporizing matter of silicide, and by the heat emitted from the second substrate pursuant to the heating, the first substrate is heated to a temperature at which silicide is vaporized from the liquid. Accordingly, it becomes possible to reduce costs for the method using the two substrates.

[0015]

In the method of the present invention, it is preferable that, before performing the step of arranging the liquid, an active region and inactive region for CVD be formed on the thin-film-forming surface so that a silicon thin-film is selectively deposited.

An active region and an inactive region for CVD are preferably formed in the following manner. A self-assembled film is formed on the thin-film-forming surface in which a hydroxyl group (OH group) exists, using a silane derivative indicated by the general formula $RSiX_3$ (R is a fluoroalkyl group in which hydrogen on an end side of an alkyl group is substituted with fluorine and X is a group that can be hydrolyzed into an OH group, for example, an alkoxy group and a hologen group), then, an ultraviolet ray irradiation through a photomask to the self-assembled film or electron beam irradiation to a necessary part of the self-assembled film is performed and a part of the self-assembled film which becomes an active region for CVD is removed. Thereby, a predetermined pattern of a silicon thin-film can be obtained without performing a patterning process after forming a film.

[0016]

A "self-assembled film" in the present invention refers to a monomolecular film in which, by, in the state of gas or liquid,

coexisting with the thin-film-forming surface a compound in which a functional group bondable to a constitutive atom on the film-forming surface is bonded to a straight chain molecule, the functional group is absorbed to the thin-film-forming surface and bonded to a constitutive atom on the film-forming surface, and in which a straight chain molecule faces outwardly. This monomolecular film is called a "self-assembled film" because it is formed by voluntary chemical absorption of a compound to the film-forming surface.

[0017]

Furthermore, there is a description of self-assembled films in Chapter 3 of "An Introduction to Ultrathin Organic Film from Langmuir-Blodgett to Self-Assembly" Academic Press Inc. Boston, 1991, and such description is incorporated as a reference into this specification.

[0018]

When a gasous or liquid silane derivative ($RSiX_3$) coexists on the thin-film-forming surface on which a hydroxyl group exists, X is first hydrolyzed by moisture in the air and becomes fluoroalkylsilanol ($RSi(OH)_3$). A siloxane bonding occurs due to a dehydrate reaction caused by a hydroxyl group of the silanol and a hydroxyl group on the film-forming surface, and a monomolecular film (self-assembled film), a fluoroalkyl group (R) facing outwardly, is formed on the film-forming surface. The surface of this self-assembled film is in an inactive state (low surface energy and low reactivity) because of the existence of the fluoroalkyl group.

[0019]

It is preferable to use, as a silane derivative indicated by the general formula $RSiX_3$, fluoroalkylalkoxysilane, e.g., (heptadecafluoro-1,1,2,2-tetrahydornalium)decyl-triethoxysilane,

(heptadecafluoro-1,1,2,2-tetrahydronalium)decyl-trimethoxysilane, (tridecafluoro-1,1,2,2-tetrahydronalium)octyl-trimethoxysilane, (tridecafluoro-1,1,2,2-tetrahydro)octyl-triethoxysilane, etc.

[0020]

Therefore, the part of the thin-film-forming surface in which a self-assembled film is removed by the above method becomes an active region for CVD, and the part of the thin-film-forming surface in which the self-assembled film remains becomes an inactive region for CVD.

[0021]

In the method of the present invention, it is preferable to perform a process of arranging liquid by an inkjet method.

In the method of the present invention, examples of substrates (a substrate on which both liquid arrangement and thin-film formation are performed, a substrate on which only liquid arrangement is performed, and a substrate on which only thin-film formation is performed) are a silicon (Si) wafer, a quartz plate, a glass plate, a plastic film, a metal plate, etc. Among such substrates, those on the surface of which a semiconductor film, a metal film, a derivative film, an organic film, etc. is formed may also be used as the substrates.

[0022]

[Mode for Carrying out the Invention]

Embodiments of the method of the present invention will be explained with reference to figure 1.

First, an ultraviolet ray was irradiated onto a thin-film-forming surface 11 of a glass substrate 1, thereby cleaning the thin-film-forming surface 11. Conditions for ultraviolet ray irradiation were the wavelength of an ultraviolet ray of 172 nm, illumination of 10 mW/cm^2, and the irradiation time of 10 minutes

were adopted. Accordingly, the thin-film-forming surface 11 of the glass substrate 1 reached the state of a hydroxyl group existing all over the surface.

[0023]

Next, a glass substrate 1 in this statewas accommodated into a sealed space. In this sealed space, an open-topped chamber containing 0.5 ml of liquid (tridecafluoro-1,1,2,2-tetrahydro)octyl-triethoxysilane (hereinafter referred to as "FAS13") was placed and left for 48 hours. Here, the chemical formula (rational formula) of FAS13 is $CF_3(CF_2)_5(CH_2)_2Si(OC_2H_5)_3$.

[0024]

Accordingly, the sealed space has an atmosphere of FAS13 vaporized from the chamber. Then, by a dehydrate reaction of a hydroxyl group of silanol, which is generated by hydrolyzing an ethoxy group of FAS13, and a hydroxyl group on the thin-film-forming surface 11 of the glass substrate 1, a siloxane bonding occurred. As a result of that, on the entire thin-film-forming surface 11 of the glass substrate 1 which is pulled out after being left for 48 hours, a monomolecular film (self-assembled film) 30 was formed in the state of a fluoroalkyl group ($CF_3(CF_2)_5(CH_2)_2$-) facing outwardly. Therefore, the surface of the monomolecular film 30 has the state of being inactive in terms of CVD. This state is shown in Figure 1 (a).

[0025]

Next, as shown in figure 1 (b), a photomask in which a pattern called "line and space", a linear ultraviolet ray shielding part 61 and a linear ultraviolet ray transmission part 62 being alternately arranged, is prepared. Then, through the photomask 6, an ultraviolet ray 2 is irradiated onto the monomolecular film 30.

The conditions of ultraviolet ray irradiation were the wavelength of 172 nm, illumination of 10 mW/cm^2, and irradiation time of 10 minutes were adopted. The line width of the line and space of the photomask 6 (the width of the line comprising the ultraviolet shielding part 61) was 30 μm and the line pitch (the width of the line comprising the ultraviolet transmission part 62) is 20 μm. The photomask 6 was prepared by, for example, forming a chromium pattern on a quartz substrate. The ultraviolet ray transmission factor of this quartz substrate of the 172 nm wavelength was approximately 60%.

[0026]

Accordingly, the part of the monomolecular film 30 which was arranged right under the ultraviolet transmission film 62 of the monomolecular film 30 was removed, and a monomolecular film pattern 30a having a linear opening 31 was formed on the thin-film-forming surface 11 of the glass substrate 1. This state is shown in figure 1 (c).

In the opening 31 of this monomolecular film pattern 30a, a thin-film-forming surface 11a of the glass substrate 1 is exposed. This exposed surface 11a has a hydroxyl group and is in the state of being active for CVD. Further, the part of the thin-film-forming surface 11 in which a monomolecular film remains (the surface of the monomolecular film pattern 30a) is in the state of being inactive for CVD. Therefore, by the monomolecular film pattern 30a, an active region and inactive region for CVD were formed on the thin-film-forming surface 11 of the glass substrate 1.

[0027]

Next, as material liquid, for example, a solution in which 8g of cyclopentasilane and 1g of silylcyclopentasilane were dissolved in

100g of toluene (hereinafter referred to as the "cyclosilane solution") is prepared. Then, the glass substrate 1 on which the monomolecular pattern 30a was formed was arranged in the nitrogen atmosphere, and the cyclosilane solution was discharged by the inkjet method to a large number of openings 31 of the monomolecular pattern 30a in every other pattern to arrange a droplet 5. This state is shown in figure 1 (d).

[0028]

Next, in this state, while running a nitrogen gas in parallel with the thin-film-forming surface 11 (which is also the liquid arranging surface) of the glass substrate 1, the glass substrate 1was heated to 350 c° and was retained for 10 minutes.

Thus, a part of the droplet 5 comprising the cyclosilane solution was vaporized to become gasous cyclopentasilane and silylcyclopentasilane, and such gases were supplied to the opening 31, in which the droplet 5 of the monomolecular film pattern 30a was not arranged. These gases are thermally decomposed by heat, and silicon was deposited into the opening 31, whereby, as shown in figure 1 (e), a silicon thin-film 50 was formed in the opening 31. On the surface of the monomolecular film pattern 30a (the part in which the monomolecular film remains), the silicon thin-film 50 was not formed. The thickness of the silicon thin-film 50 was, for example, 20nm.

[0029]

Further, in the opening 31 in which the droplet 5 was arranged, cyclopentasilane and silylcyclopentasilane in the cyclosilane solution which were not vaporized were thermally decomposed and a silicon film 51, the thickness of which was, for example, 50 nm, is formed.

A second embodiment of the method of the present invention

will be explained with reference to figure 2.

Two glass substrates 7 and 8are prepared, and on one side of each of the surfaces of both glass substrates, patterns 30a and 30b comprising a monomolecular film (self-assembled film) were formed by the same method as in the first invention, using FAS 13. That is, on a liquid arranging surface 81 of a first substrate 8 and a thin-film-forming surface 71 of a second substrate 7, the patterns 30a and 30b of a monomolecular film which have a same form when they were facing each other, were formed.

Here, a photomask, in which a round ultraviolet ray transmission part having the diameter of 50 μm was reticularly arranged at the picth of 5 mm, was used. Accordingly, the monomolecular film patterns 30a and 31b also have a form in which a round opening 31 is reticularly arranged. Further, alignment marks were formed in the four corners of the photomask and such marks were transcribed to the monomolecular film patterns 30a and 30b, which is a preferred manner.

[0031]

Next, the first substrate 8 was arranged in a nitrogen gas atmosphere such that the surface (liquid arranging surface) 81, on which a monomolecular film pattern 30a was formed, facing upwards. Then, the same liquid (cyclosilane solution) as in the first embodiment was discharged by an inkjet method into all openings 31 of the monomolocular pattern 30a to arrange a droplet 5.

Next, the second substrate 7 was arranged such that the thin-film-forming surface 71, on which a monomolecular film pattern 30b was formed, faces downwards and was set above and in parallel with the first substrate 8 at a predetermined distance (e.g. 1 mm). In the case of this arrangement, alignment marks formed on the

monomolecular film patterns 30a and 30b of the substrates 7 and 8 were aligned and the opening 31, in which the thin-film-forming surface 71 of the monomolecular film pattern 30b of the second substrate 7 was exposed, and the opening 31, in which the droplet 5 in the monomolecular film pattern 30a of the first substrate 8 was arranged, were aligned. This state is shown in figure 2 (a).

[0032]

Next, as shown in figure 2 (b), in this state, while running a nitrogen gas between substrates 7 and 8 and in parallel with the substrate surface, the second substrate 7 was heated to 450 °c, and retained for 10 minutes. Thus, the first substrate 8 was indirectly heated by the heat emitted from the second substrate 7 and a part of a droplet 5 on the first substrate 8 comprising the cyclosilane solution was vaporized and supplied into the opening 31 of the monomolecular pattern 30b of the second substrate 7.

[0033]

As a result, gaseous cyclopentasilane and silylcyclopentasilane vaporized from the droplet 5 were decomposed by heat and silicon was deposited in the opening 31 of the monomolecular pattern 30b of the second substrate 7 and, as shown in figure 2 (c), a silicon thin-film 50 was formed in this opening 31. The silicon thin-film 50 was not formed on the surface (the part in which a monomolecular film remains) of the monomolecular film pattern 30b. The thickness of the silicon thin-film 50 was 50 nm.

[0034]

Further, even though the temperature of the droplet 5 in the opening 31 of the first substrate 8 did not reach the temperature to decompose cyclopentasilane and silylcyclopentasilane, all of solvents in the cyclosilane solution vaporized. Consequently, in the

opening 31 of the first substrate 8, an oily matter 53 comprising cyclopentasilane and silylcyclopentasilane, which was not vaporized from the droplet 5, remained.

[0035]

As described above, according to the method of the first and second embodiments, by the cyclosilane solution being arranged on a part of a substrate and then vaporized, a silicon film can be easily formed by a CVD method on a part of the substrate, using a small amount of material liquid. Further, by using an inkjet method, the liquid can be arranged easily and accurately. Moreover, before arranging the cyclosilane solution, a monomolecular pattern is formed on the thin-film-forming surface and the opening of the monomolecular thin-film pattern is selectively deposited; therefore, a silicon thin-film pattern can be obtained without performing a patterning process after forming the thin-film.

[0036]

Particularly, according to the method of the second embodiment, since two sheets of substrates 7 and 8 are arranged facing each other and each vaporizing matter from a droplet 5 faces each opening 31 of the monomolecular film pattern 30b, the uniformity of the film thickness in an opening 31 and the uniformity of the film thickness between a plurality of openings 31 are enhanced.

Further, by forming a monomolecular pattern 30a also in the first substrate 8, an arranging region (opening 31) of a droplet is formed on a liquid arranging surface 81 to arrange a droplet 5 in each opening 31; therefore, in comparison to the case in which such region is not formed, the amount of the materials used can be reduced. Furthermore, the accuracy of the position to arrange a droplet can be enhanced.

[0037]

Moreover, only the second substrate 7 is directly heated and the first substrate 8 is indirectly heated by the heat emitted from the second substrate 7; therefore, the cost for heating can be reduced.

[0038]

[Effects of the Invention]

As explained above, according to the present invention, a silicon thin-film can be formed on a part of a substrate by using a small amount of a liquid material.

Particularly, according to the method described in Claim 7 of the present invention, it is possible to obtain a predetermined pattern of a silicon thin-film without the necessity to perform patterning after forming the thin-film.

[0039]

Further, according to the method described in Claim 9 of the present invention, liquid can be easily and accurately arranged.

[Brief Description of the Drawings]

[Fig. 1]

Fig. 1 is a view illustrating a method of the first embodiment of the present invention.

[Fig. 2]

Fig. 2 is a view illustrating a method of the second embodiment of the present invention.

[Description of Reference Numerals]

1 Glass substrate

11 Thin-film forming surface

11a Exposed surface of thin-film forming surface

2 Ultraviolet ray

30 Monomolecular film (self-assembled film)

30a	Monomolecular film pattern
30b	Monomolecular film pattern
31	Opening
5	Droplet
50	Silicon thin-film
51	Silicon film
53	Oily matter
6	Photomask
61	Ultraviolet ray shielding part
62	Ultraviolet ray transmission part
7	Glass substrate (second substrate)
8	Glass substrate (first substrate)

[Document Name] Abstract

[Abstract]

[Object] To provide a method of forming a silicon thin-film in a CVD method without the necessity to perform patterning after forming the thin-film.

[Solving Means] Patterns 30a and 30b comprising a monomolecular film are formed on a liquid arranging surface 81 of a first substrate 8 and a thin-film forming surface 71 of a second substrate 7, using (tridecafluoro-1,1,2,2-tetrahydro)octyl-triethoxysilane. Droplet 5 comprising cyclosilane solution is arranged in opening 31 of the monomolecular pattern 30a of the first substrate 8. Both substrates 7 and 8 are arranged in parallel at a predetermined distance while the openings 31 of both substrates were aligned. While running a nitrogen gas between substrates 7 and 8, the second substrate 7 was heated to 450 °c, and retained for 10 minutes, whereby, droplet 5 was vaporized and supplied into the opening 31 of the second substrate 7. Thus, a silicon thin-film 50 is formed.

[Selected Drawing] Fig. 2